# NASA Aviation Safety Program

## 3rd Annual Weather Accident Prevention Review

MIT / Lincoln Laboratory
Lexington, MA
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# Objectives of Review



- Communicate progress to NASA's stakeholders, partners and customers
- Solicit feedback on NASA's aviation weather safety activities and plans
- Further encourage and strengthen NASA's collaboration with the aviation community
- Support internal communication and integration of NASA weather accident prevention activities
- Provide input to assist NASA's definition of detailed research for FY03 and beyond

# Today's Agenda



## Morning

- NASA Project Overviews & Status
- FAA Weather Programs Overview & Status
- Industry Partner Briefings

## Afternoon

- Parallel Technical Breakout Sessions:
  - Aviation Weather Information
  - Weather Information Communications
  - Turbulence Prediction & Warning Systems

# Tomorrow Morning's Agenda



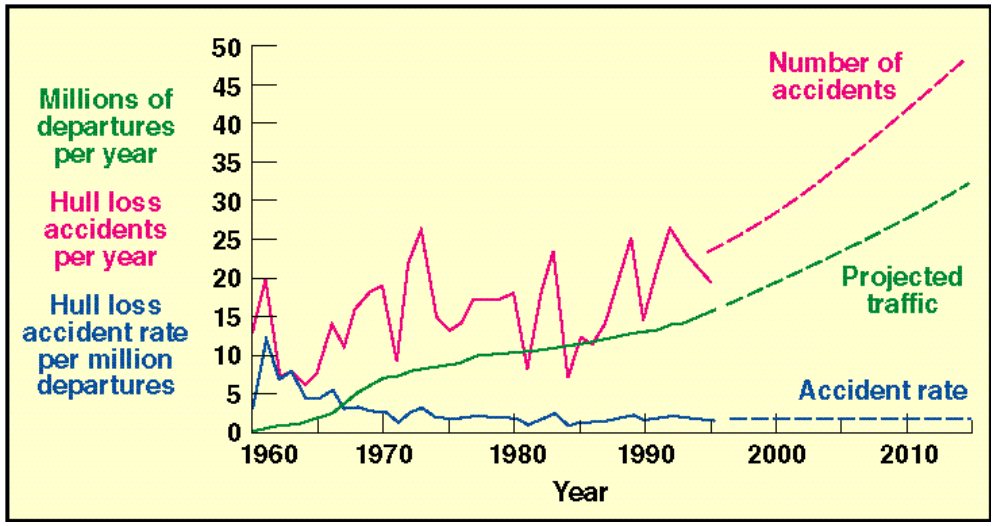
- NASA Future Plans
- Panels:
  - Commercial Air Transport Stakeholder Panel
  - General Aviation Stakeholder Panel
  - Technology System Implementation Panel
- Wrap-up

# Weather Accident Prevention Project Overview & Status

# Weather and Aviation Safety



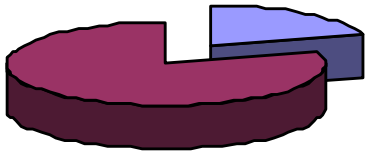
**National Safety Goal:** Reduce the aircraft accident rate by a factor of five within 10 years (2007), and by a factor of ten within 25 years (2022).




Non-Turbulence-related Injuries (67%)

Turbulence Injuries (33%)

***Ranked #1 for Injuries***



**Commercial Transport Serious Injuries 1990-1996**

Fatal/Non-fatal Accidents

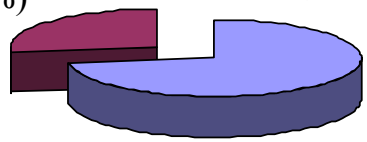
Source: NTSB Data

41% during cruise

27% due to visual flight operation in instrument flight conditions

Weather-related (27%)

Non-weather-related (73%)

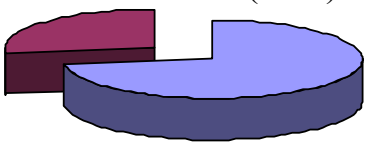


**GA Aviation Accidents 1982-1993 (22,053 total accidents)**

Source: AOPA Air Safety Foundation

Weather-related (33%)

Non-weather-related (67%)



**Commercial Carrier Accidents 1983-1995**

Source:NTSB

# Research Plan Drivers



- Aviation Safety Investment Strategy Team Recommendations (ASIST)
- National Aviation Weather Initiatives and Plans
- NASA-FAA-Industry Joint Safety Assessment and Implementation Teams (JSAT/JSIT)
- Integration with other NASA Projects
- NASA/Other Agency/Industry Workshops & Reviews (THIS REVIEW)
  - External: Industry Reviews, AvSPEC, NASA/FAA JWG
  - Internal: Program Mgt Reviews, Semi-annuals, Independent Implementation Reviews…

# Weather Accident Prevention Project



**Goal**

Develop enabling technologies to reduce weather-related accident causal factors by 50% and turbulence-related injuries by 50% by the year 2007.

**Objectives**

- Provide the Flight Deck with Higher Fidelity, More Timely Intuitive Graphical Information
- Detect & Mitigate Weather Hazards

**Challenges**

- Weather-related Threat Characterization
- Multi-purpose sensor systems and displays
- Real-Time Datalink Communication

**Approaches**

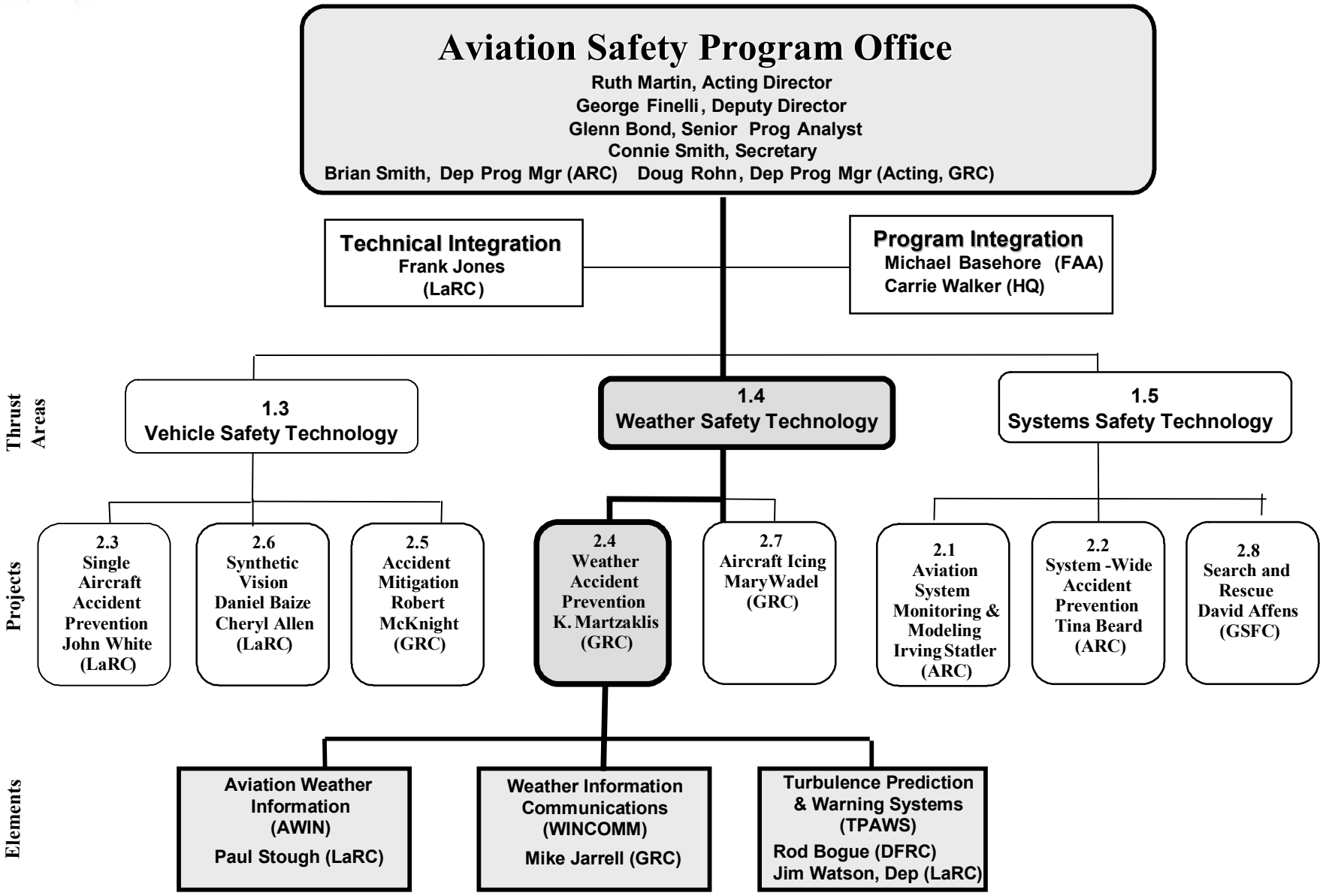
- Develop Weather Products, Displays and Decision Tools for Cockpit Use
- Aircraft as Airborne Wx Data Collectors
- Revolutionize Aircraft/Ground, and Aircraft/Aircraft Information Exchange

**Elements**

- Aviation Weather Information (AWIN)
- Weather Information Communications (WINCOMM)
- Turbulence Prediction & Warning System (TPAWS)

# Program Organization





# Key Facilities



Langley B-757

Glenn Lear Jet

Glenn Icing Research Tunnel

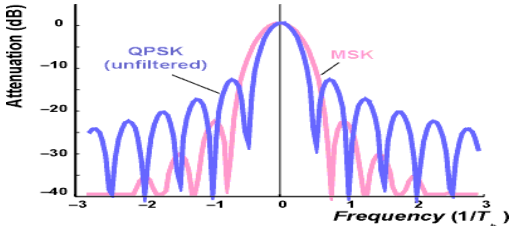
Glenn Twin Otter

Simulators

Dryden DC-8

## Also:

- Langley Cessna 206, B-200
- Langley G/A and transport category simulators
- Glenn AeroComm Labs




Glenn Comm Modeling/Sim Lab

# Products



- Datalink Cockpit Weather Information Systems
  - General Aviation systems
  - Commercial Air Transport systems
- Focused Cockpit Weather Technologies
  - User interface:
    - Presentation, decision aiding, flight planning tools
  - Information acquisition & conditioning:
    - Information fusion, enhanced on-board radar, advanced satellite aviation-weather products
  - Communications ground-air technologies:
    - Portable avionics, adaptation of non-Wx comm

Cross-cut:

- CONOPS & requirements
- Architecture guidelines
- Modeling & simulation
- Market & trade studies
- Cost/benefit analyses

# Products (Continued)



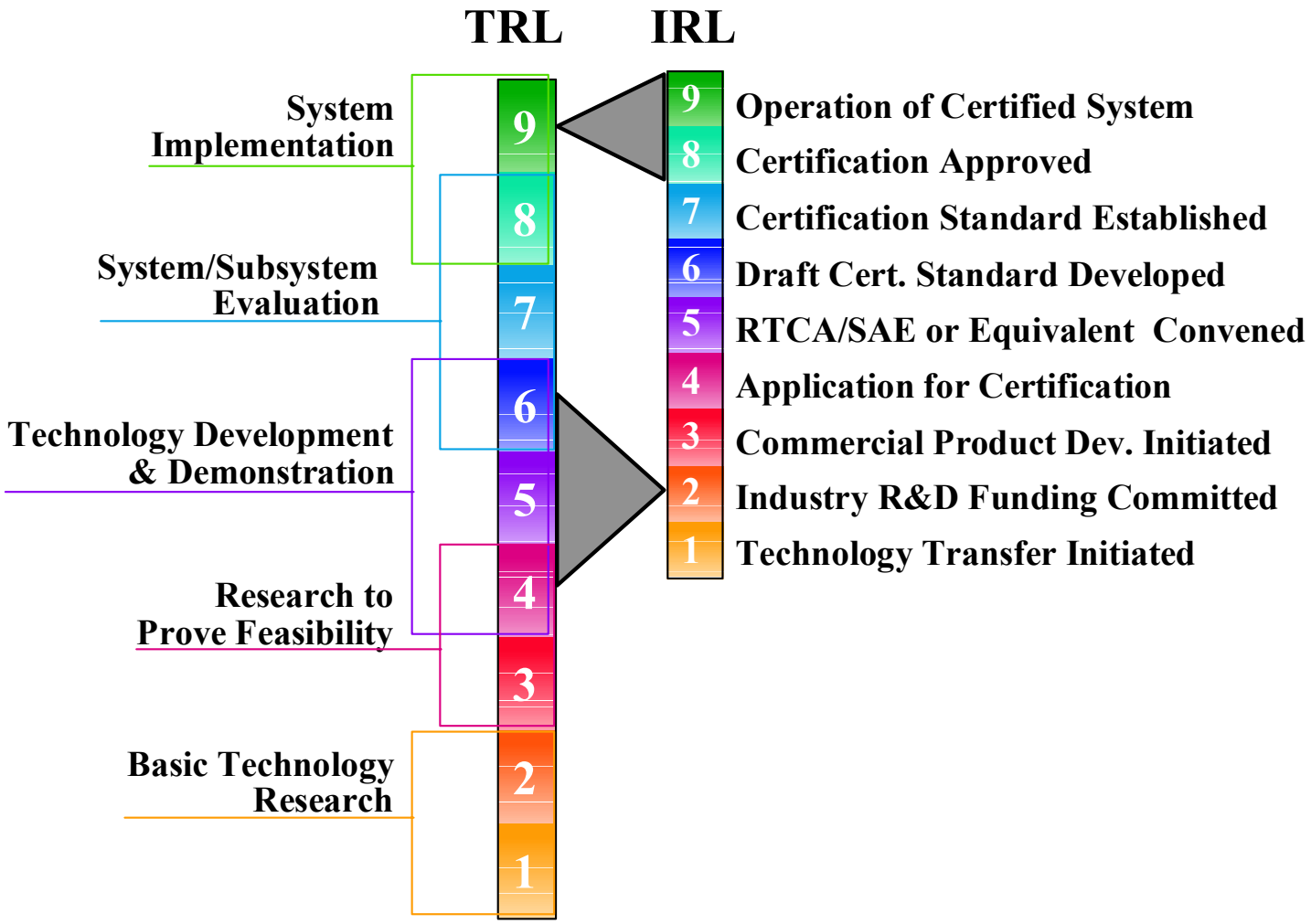
- Airborne Weather Reporting Technologies
  - Sensors technologies
  - Communications air-air, air-ground technologies
- Turbulence Technologies:
  - Turbulence Modeling & Simulation
  - Airborne Turbulence Sensors
  - Turbulence In-situ Systems
  - Turbulence Prediction Algorithms & Hazard Metrics
  - Flight Deck Integration
  - Enhanced autopilot concepts for turbulence ride smoothing
  - Certification Methods & Tools

Cross-cut:

- CONOPS & requirements
- Architecture guidelines
- Modeling & simulation
- Market & trade studies
- Cost/benefit analyses

# Technology & Implementation Readiness





# WxAP Products & Decision Process

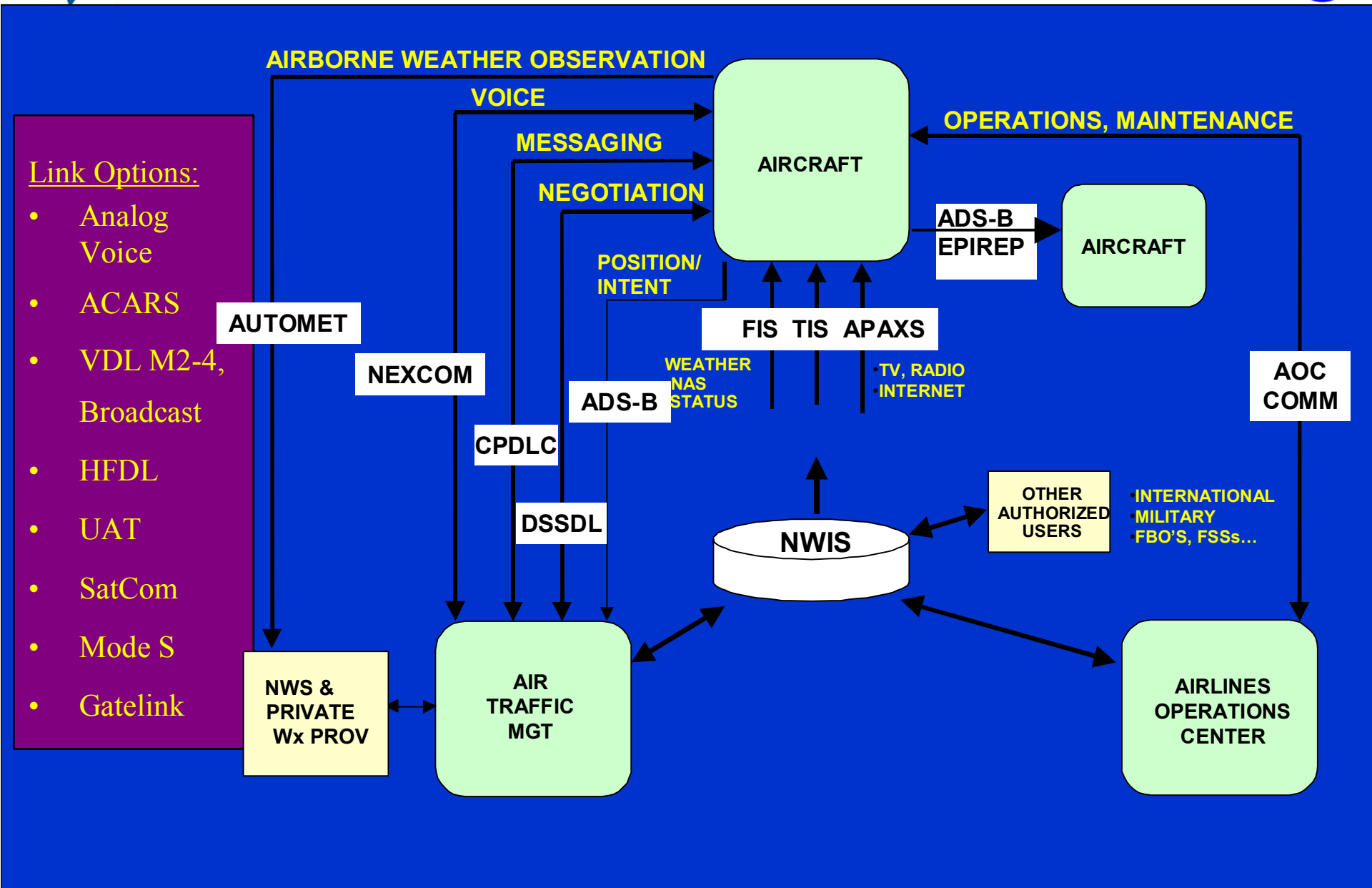


Weather Products
Distribution
Presentation

Aircraft Capabilities
User Capabilities
Decision Aids
User Interface
Processor
Presentation
Data Link
Airborne Wx Report
Onboard Sensors
Flight Information
Navigation Information
Position
Flight Plan
Ground Wx System
Weather Products
Data Link
Traffic
Terrain
Special Use Airspace
Obstacles
Satellite Observations

# Information Exchange in the NAS

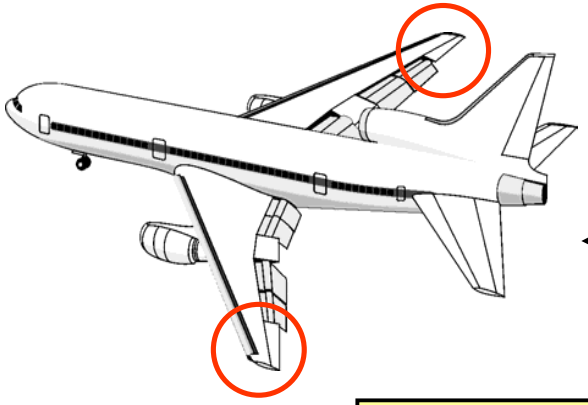




# Turbulence Product Architecture

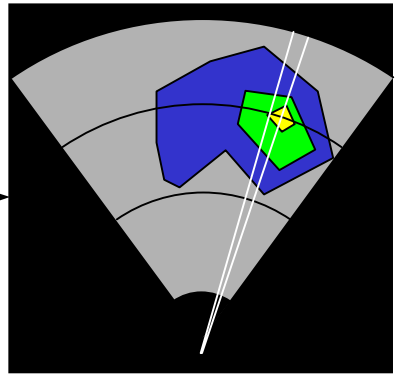


Flight Management System A/C Controls/Mitigation Schemes



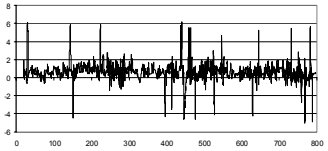
Decision Aids

Presentation to Pilot



Processor

Onboard Sensors



Automet

Data Link

Turbulence Information

Turbulence Products

Ground Wx System

Data Link

Forward-Looking Sensors: Radar and LIDAR

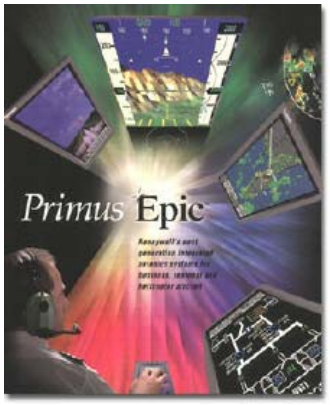
# Commercial Transport Systems



Honeywell Weather Information Network Cooperative Research:

NASA Evaluation
of AWIN System on NASA B-757

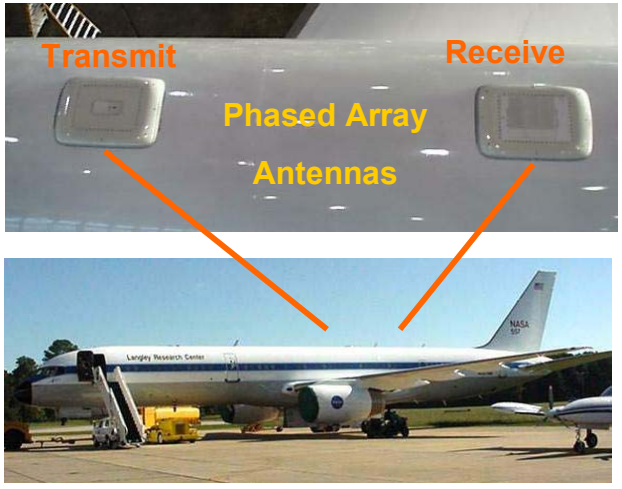
In-Service Evaluation
by United Airlines on Airbus




WINN selected
for Honeywell Epic Avionics

Boeing Broadband Satellite Communications Research:

Airborne Equipment Rack



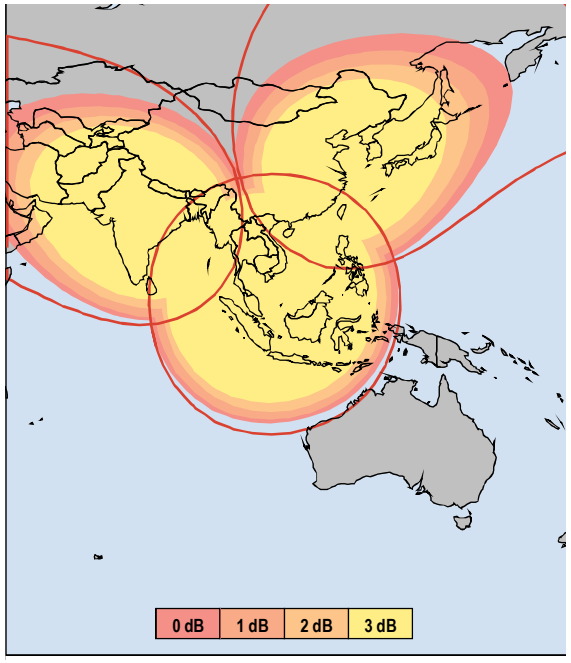

Antenna Installation on NASA B-757


Flight Track (from Spring 2002)

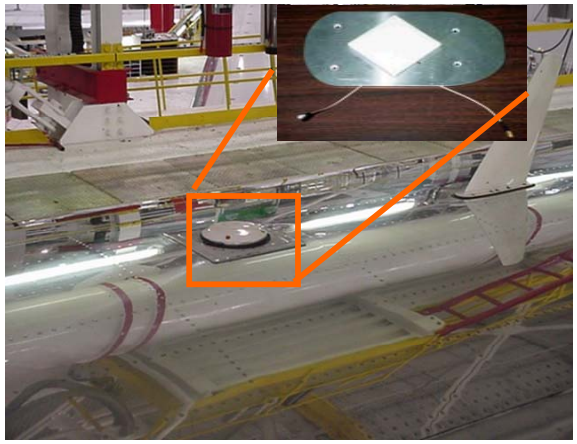
# Commercial Transport Systems



Rockwell Satellite Weather Information Service (SWIS) Research:

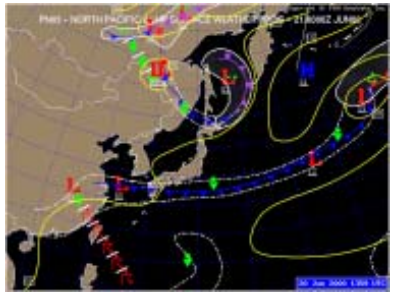



AsiaStar Antenna Beam Coverage

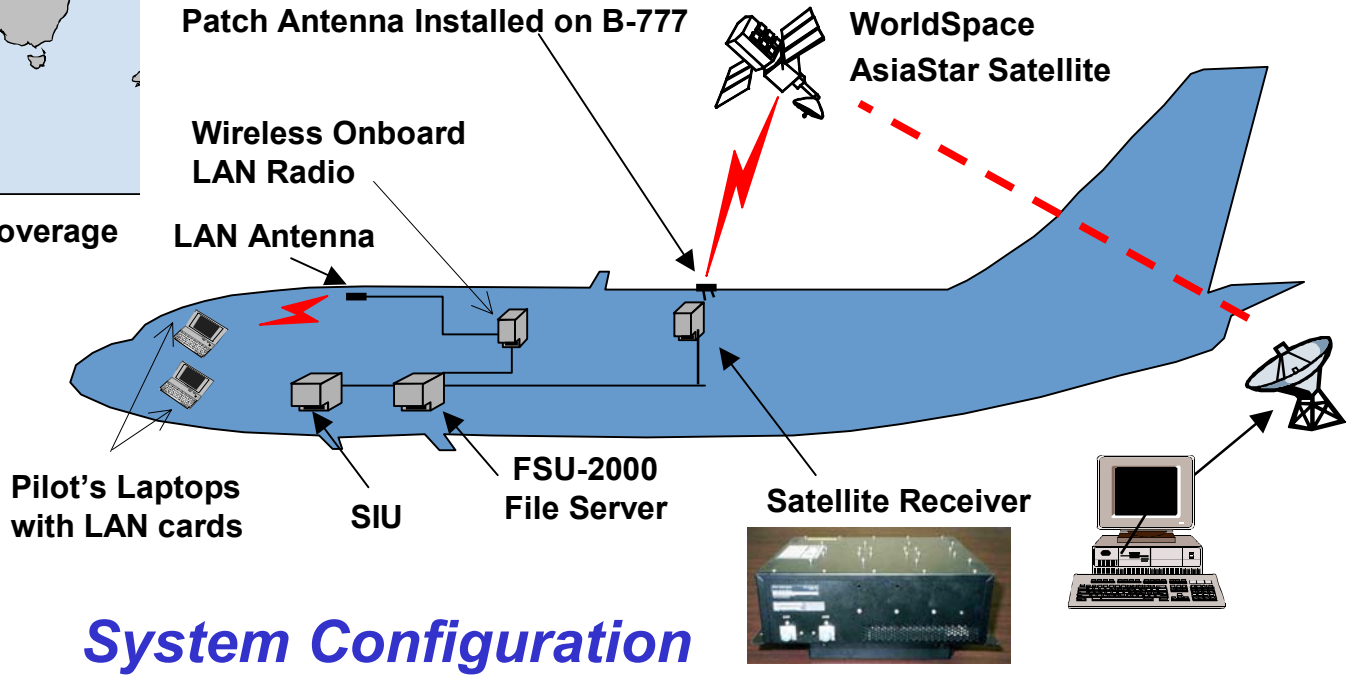


Patch Antenna Installed on B-777

- Completed In-Service Evaluations on NOPAC routes with two American Airlines B-777s
- Demonstrated good link performance
- Favorable crew feedback
- Major concern: high comm costs



Sample Weather Image




## System Configuration

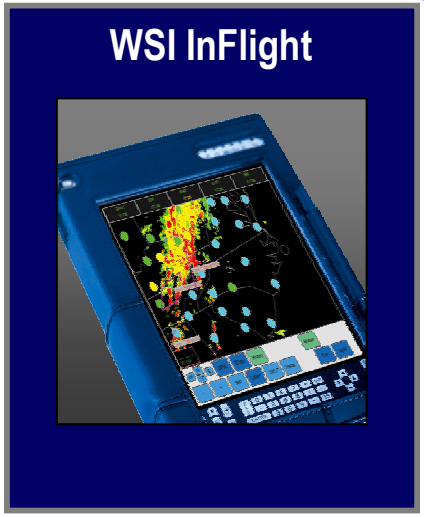
# General Aviation Systems



ViGYAN Small Business Innovative Research:

2000-2001: Initial Flight Evaluation under NASA SBIR Contract

Antenna Aircraft Installation

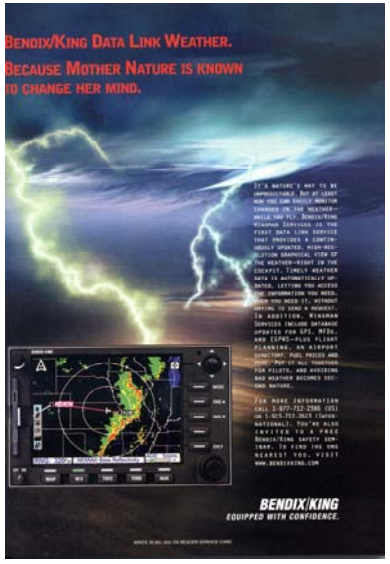



Summer 2002: WSI InFlight Product

Cooperative Research with ARNAV and Honeywell/Bendix-King:

Summer 2000 - NASA AWIN General Aviation System Research on NASA B-200 King Air

Summer 2000 - ARNAV General Aviation Data Link Weather Information System




December 2001 - Bendix/King General Aviation Data Link Weather Information System

# Commercialization



- AirCell
- ARNAV Systems Inc.
- Avidyne
- Baron
- ControlVision
- Echo Flight
- FlyTimer
- Garmin
- Goodrich
- Honeywell/Bendix-King
- SATELLINK Technologies
- WSI

T2GO2R

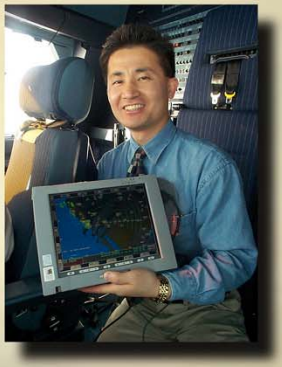
Objective 1

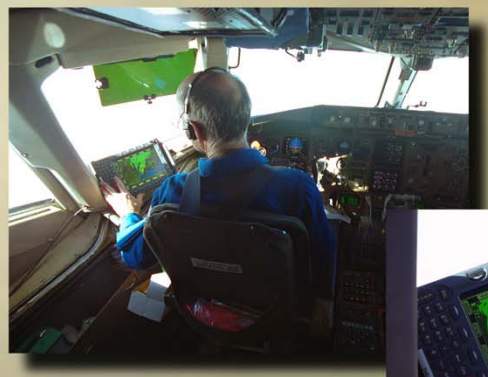
# Aviation Safety

## Aviation Weather Information and Communications Research Team

**Team Members:** NASA Langley Research Center, NASA Glenn Research Center, Honeywell International, Incorporated,ViGYAN, Incorporated, Federal Aviation Administration, Rockwell Collins, United Airlines

The Aviation Weather Information & Communications Research Team developed weather presentation and communications technologies resulting in cockpit weather information systems being introduced into the marketplace. Glenn and Langley researchers worked with the Federal Aviation Administration (FAA), industry and academia to achieve better crew situational awareness. It is anticipated that these systems will result in a 50% reduction in aircraft accidents attributable to a lack of weather awareness. In addition, more than 60% of air traffic delays are attributed to weather, and the technologies developed will significantly improve operational efficiency by allowing strategic avoidance of weather.



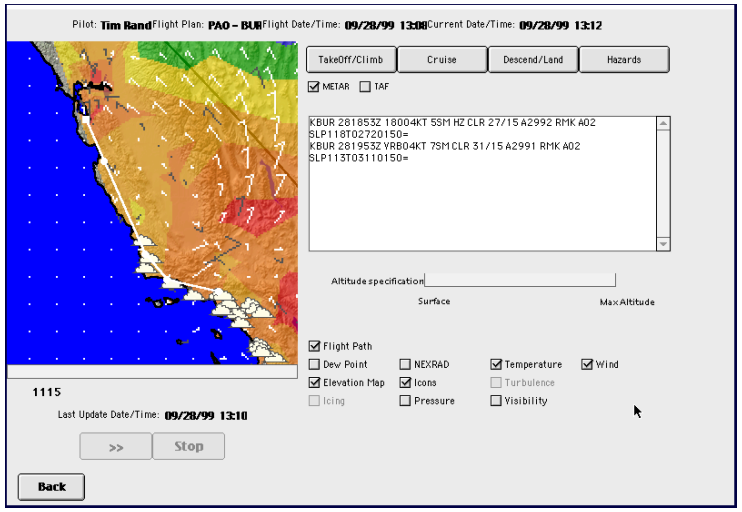


Santa Clara, CA

# User Interface Research



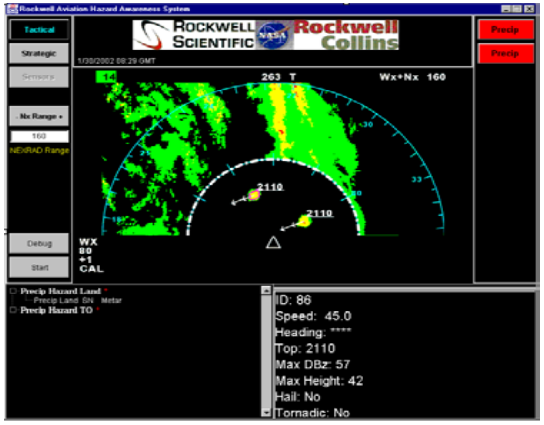

Enhanced Weather Radar: Integrating on-board & uplinked Radar




Preflight Planning: preflight probabilistic hazard analysis using text and graphic Wx information

Flight research on use of datalink weather in combination with other sources

Flight research on flying and accessing weather information (workload and relative position)

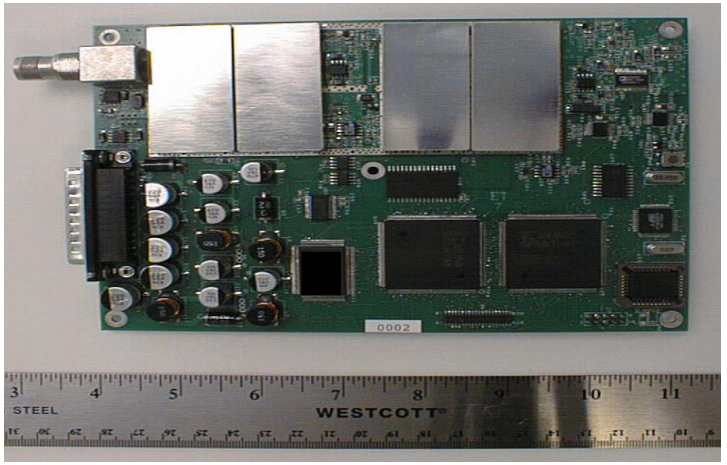



In-flight weather analysis tools considering Wx info and specific mission and equipment profile.

# Communications Research

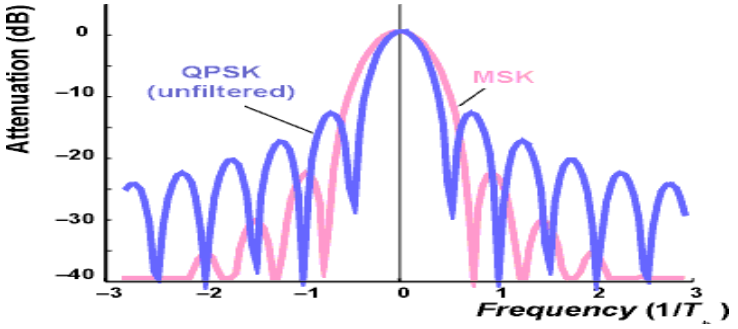


Low-cost, high performance
antenna development




Miniaturized, portable avionics
(System-on-a-Chip)

Adapting datalinks
for weather applications

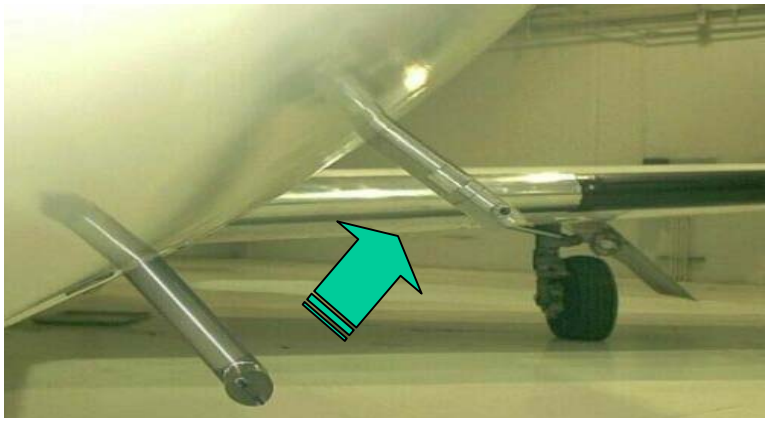



Efficient bandwidth/coding techniques

# Airborne Weather Reporting

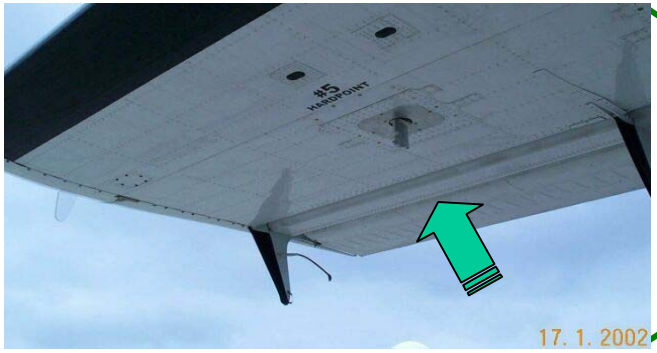



Testing of sensors in Glenn Icing Research Tunnel.



Sensor mounted to nose of UND Cessna Citation II

TAMDAR sensor (External probe)

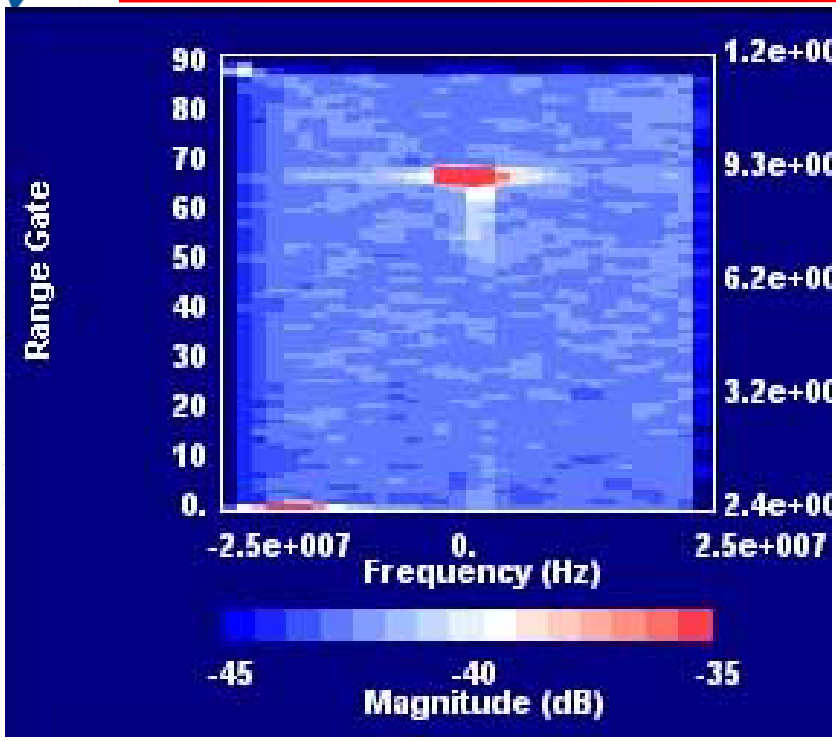


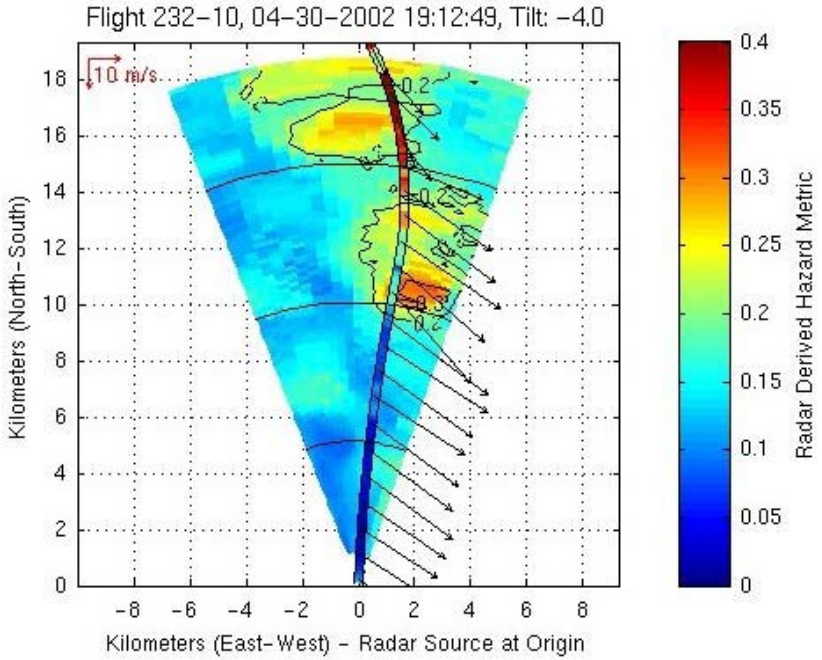

TAMDAR sensor mounted under wing for flight tests.

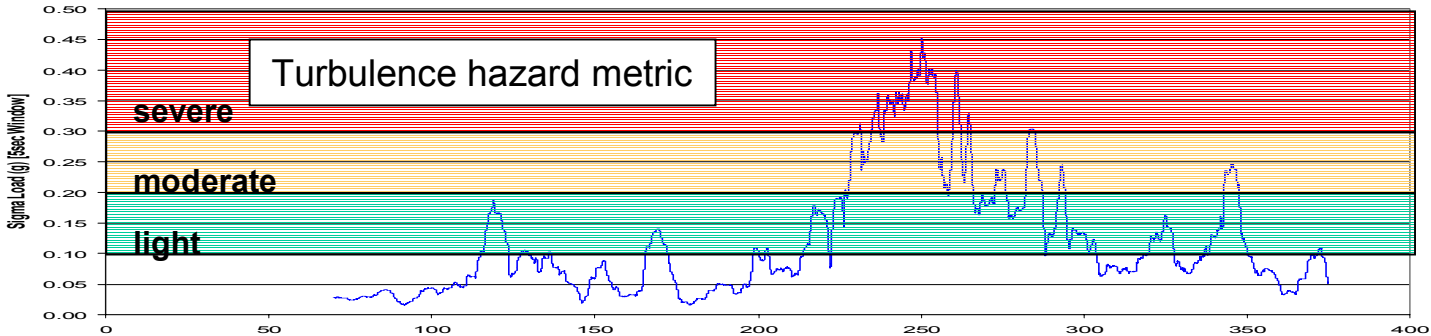
NASA Glenn Twin Otter

# Turbulence Prediction & Warning





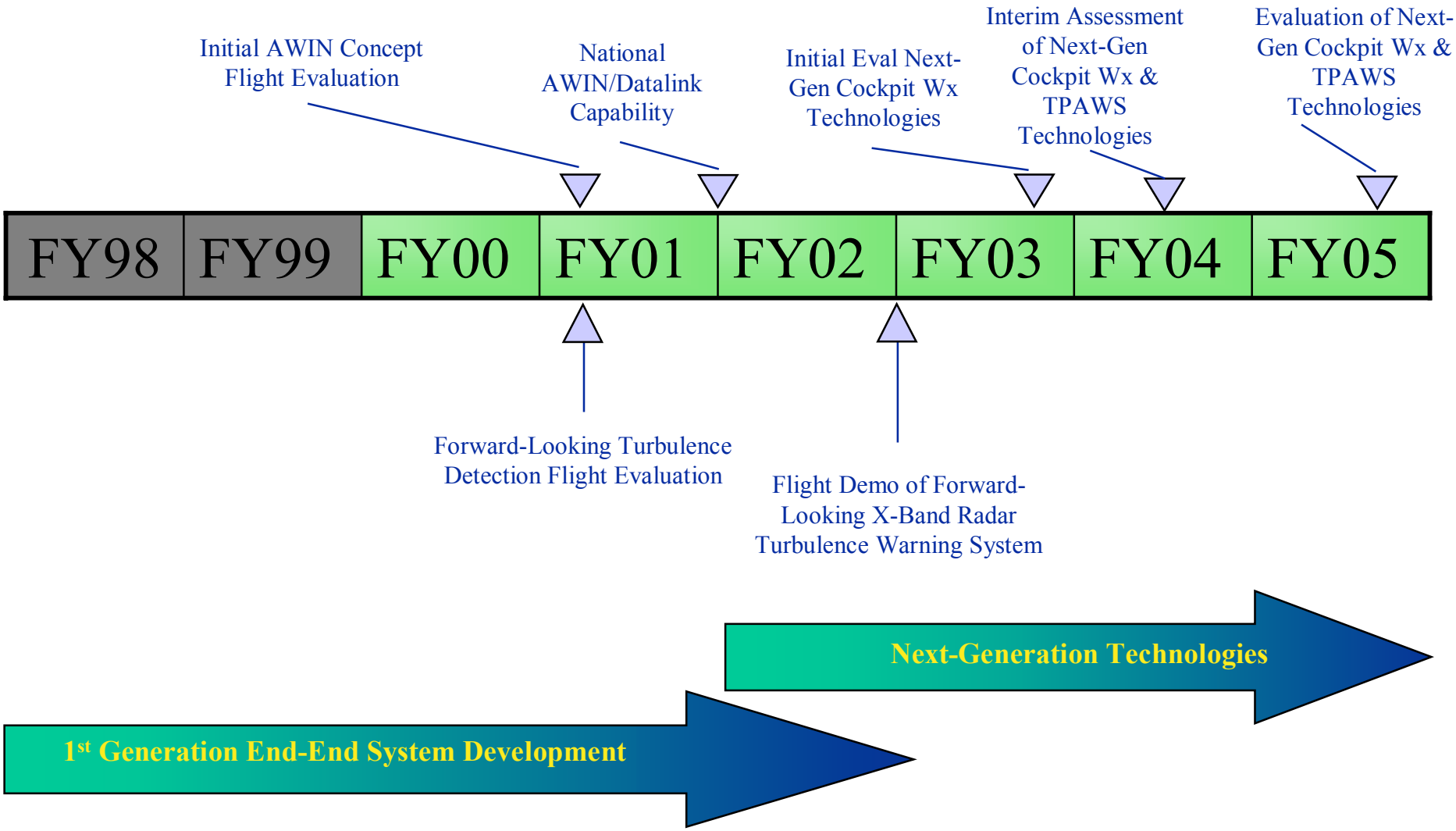




**Bottom Left Clockwise: LIDAR hardware and DC-8 installation; LIDAR backscatter; Radar reflectivity and hazard maps with in-situ overlay from B-757 flights; Turbulence hazard metric**

# Roadmap & Key Relevant Milestones

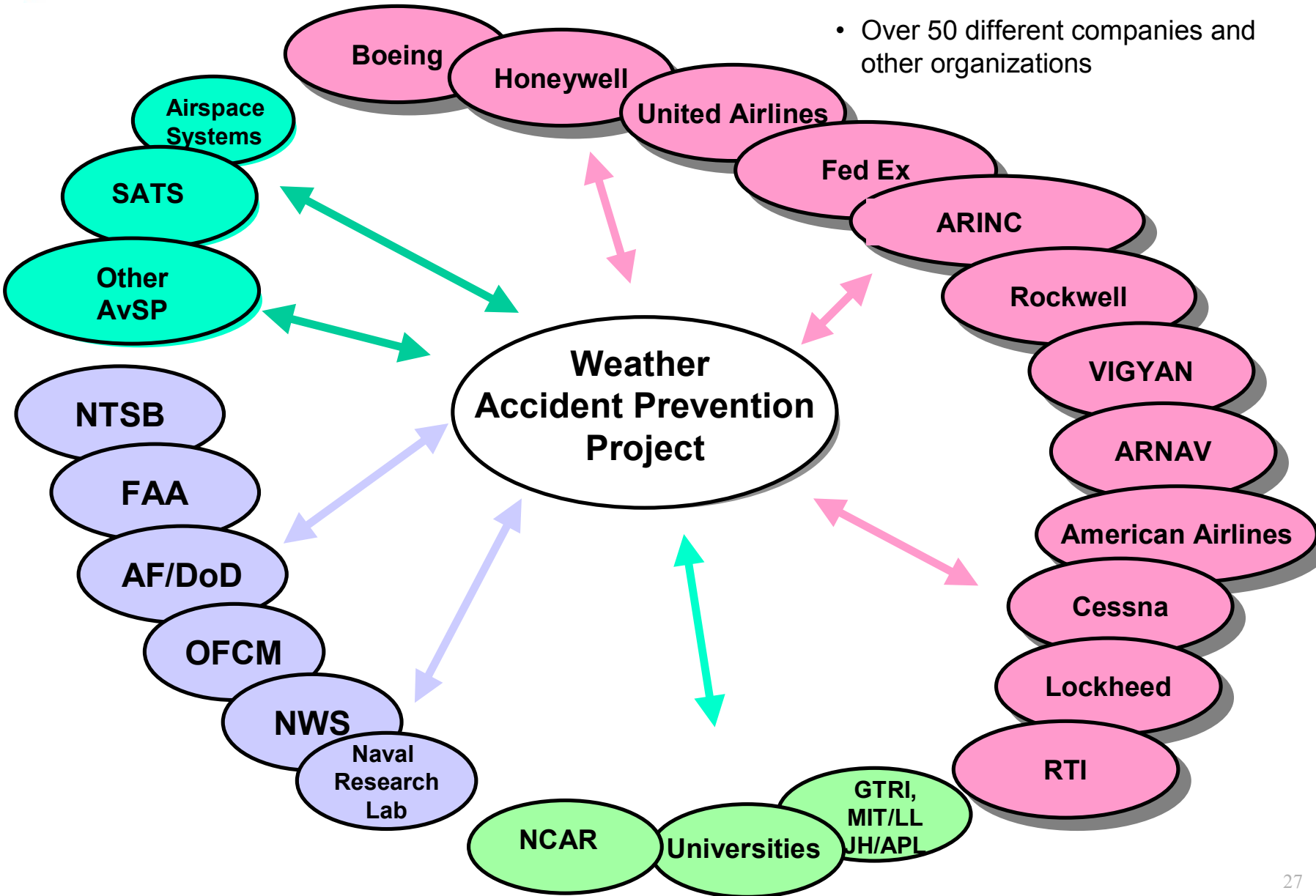




# Partners



- Over 50 different companies and other organizations



# Partner Roles



- FAA
  - Aviation weather product R&D with ground-use focus
  - Flight standards, certification, NAS ATC ops
  - Provides aviation spectrum for & flight qualifies Wx products
- NOAA/NWS
  - Wx observations & fundamental weather info for general use
- Industry
  - For fee, value-added Wx products for ground and airborne users
  - Avionics (displays, datalink systems..)
  - Commercializes airborne Wx systems
- NASA WxAP
  - Aviation weather R&D for airborne use
  - Ultimately transition technologies to FAA and industry partners

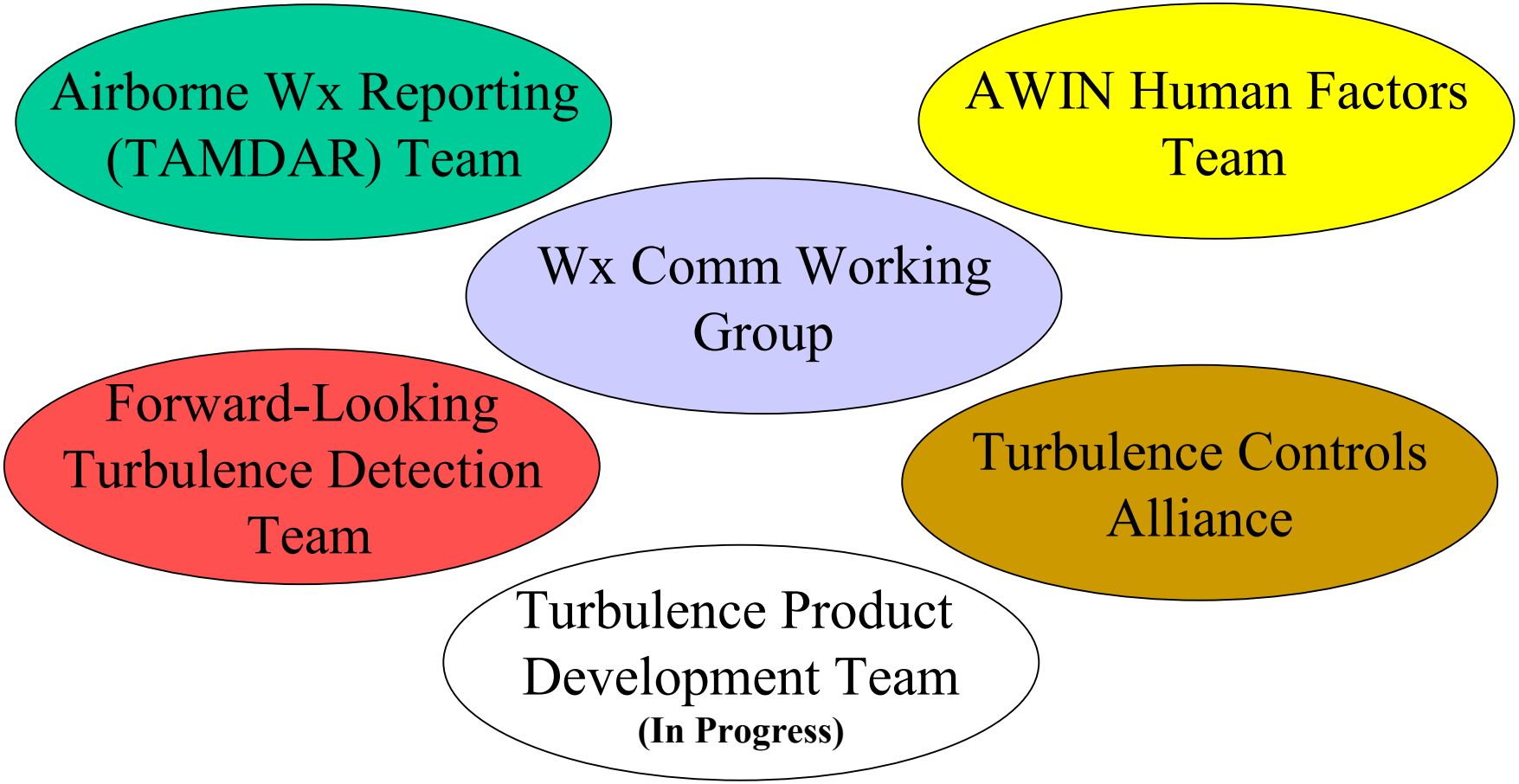
# Teaming Arrangements



- NASA-FAA Integrated Safety Research Plans
  - ➢NASA-FAA MoA on Weather Safety research in place
    - ➢Numerous jointly funded Inter-Agency Agreement tasks
  - ➢FAA Safer Skies: JSAT/JSIT teams
  - ➢NASA-FAA Joint Working Group on AvSafety: Integrated roadmaps on atmospheric hazards
- NASA-NWS Research Plans
  - ➢NASA-FAA Space Act Agreement on Wx Accident Prevention
- Tri-agency (NASA/FAA/NOAA) Collaboration Teams
- Multiple NASA-Industry Cooperative Research Agreements
  - ➢ARNAV, Honeywell, Boeing, Rockwell and others

# NASA/FAA/NOAA/Industry Teaming






- NASA-FAA Memorandum of Agreement in place
- NASA-NWS Space Act Agreement in place

# Knowledge Transfer



- SAE General Aviation Technology Conference
  - Numerous papers presented this year
  - Oral presentation award
- WxAP Annual Reviews
  - 2000 held at Hampton, VA; 2001 held at Cleveland, OH
- Friends/Partners of Aviation Weather Forum
  - WxAP on provider panels (Obs, dissemination)
  - Chair Cockpit Dissemination Panel (2001, 2002)
- Oshkosh/Airventure: annual presence
- RTCA participation
- Published at AIAA, DASC, Satellite Comm conferences

# In Summary, NASA…



- Has strong, demonstrated partnerships with aviation community
  - FAA/Industry/NOAA/Academia
  - MoAs, SAAs, CRAs…
- Has unique competencies, skills and facilities to address critical research questions
- Has strong record of technology & knowledge transfer